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DETERMINATION OF THE EFFECTIVE HEIGHT OF THE NOCTURNAL LUMINOUS LAYER

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Nocturnal luminosity consists basically of three components: atmospheric, stellar, and zodiacal light. About 40 percent of the nocturnal radiation in a moonless night comes from the earth's atmosphere. In the spectrum of nocturnal radiation we have an unbroken spectrum on which a row of lines are placed. The most noticeable are an intense green line 5,577 A of metastable oxygen, a yellow sodium line 5,893 A, and, in the red part of the spectrum, the oxygen lines 6,330 and 6,360 A, appearing as two components of a triplet. Furthermore, in the blue and violet parts of the spectrum there are a large number of emission bands: positive and negative series of molecular nitrogen. These bands are not too well separated on continuous background. With the aid of a photoelectric nebular spectrograph with an exposure of 30-35 hours it is possible to notice their traces on a photographic plate.

The determination of the effective height of luminosity of the ionosphere layer was done by my spectroscopic method. The nocturnal spectrum was photographed on Agfa Isopan F film simultaneously at several zenith intervals from the zenith of Z=80°. By determining the ratio of brightness of the separate emission lines at various zenith intervals, the height of their luminosity can be determined.

The theory of the problem of the effective height of the emitting layer leads to the following equation which determines the brightness of the sky.

$$J_{z_0} = J_0 \frac{(1+h)(P+x)\sec z}{\sqrt{(1+h)^2-\sin^2 z}} \qquad (1)$$

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This equation is established with the assumption that observations are carried out nearly at right angles ($A \approx 90^\circ$) where the influence of the latitudinal effect is nil. I kept such an arrangement when setting up the spectrograph [1].

In this equation J_0 signifies the brightness of the emitting layer at the zenith point above the observer, P is the coefficient of transmission, and X is a factor accounting for the influence of diffused light.

As was shown by V. G. Fesenkov, with coefficients of transmission $P > 0.80$, i.e., normal transmission, this factor (X) has a value of 0.03; h is the height of the emitting layer in fractions of the earth's radius.

According to this equation, taking the determined coefficient of transmission and also given the height of the emitting layer, it can be determined that the fluctuations of the brightness of this layer are dependent on the zenith interval.

The apparatus at these observations was a photoelectric nebular spectrograph constructed at the Astronomical Institute [2].

The spectrograph is distinguished chiefly by the arrangements of the prisms. There are two prisms which have similar refraction angles with an accuracy up to 2" and which are parallel to each other, acting as one large prism. Such an arrangement decreases absorption loss and also facilitates operations with the entire spectrograph. The spectrograph has a Schmidt camera and a mirror-like collimator. Schmidt's lens has a working diameter of 160 mm and a focus of 173.8 mm. The diameter of the reflector of the collimator is 200 mm with a focus of 970 mm. The working aperture has a length of 50 mm and is arranged horizontally. Schmidt's camera has a light ratio of 1:1 and give a dispersion of 112A/mm in the region of 5,500 A. The reflectors of the camera and collimator are aluminum plated. The entire spectrograph is enclosed in a plywood casing.

The prisms with complete internal reflection were place over the aperature, by which it was possible to photograph simultaneously parts of the sky at zenith intervals of 0, 45, 70, and 78°.

The adjustment of the prisms on corresponding zenith intervals was done by the auto-collimation method.

A vertical aperture with a slide is placed at a certain interval X from the prisms and a mirror is placed at the aperture. Then, noticing the position of the graduation line of the aperture on the mirror, at certain intervals Y of the slide from the horizontal area, and changing the gradient of the prisms, the image of the edge of the slide and eye ball can be seen on the mentioned graduation line. Then $\tan \alpha = \frac{Y}{X}$ where α is the angle of slope of the prism to the horizon. The zenith interval will be equal to $Z = 90 - \alpha$.

The accuracy of the adjustment of the zenith interval was close to 30'; the calibration of the film was taken with the standard spectrograph of the optics laboratory of the Astronomy and Physics Institute of the Academy of Sciences of the Kazakh SSR. On the aperture of the standard spectrograph a Zeiss spectrograph-type platinate clearing agent was placed. A spherical illuminator was used as the source to illuminate the aperture and the clearing agent. The internal part of the hemisphere was coated with a film of magnesium vapor. It had a cap with an opening in the center. Within the cap were placed flashlight bulbs. Such an arrangement gives, within determined limits, a uniformly lit field. The current of the bulbs was regulated by a rheostat.

The light of the illuminator was yellow. Uniformity of the filament current was checked by an ammeter. The exposure was the same, both in the

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nebular spectrograph and in the standard. The same exposure intervals were maintained during calibration at night observations.

The measurements of the spectrogram were carried out on a Hartman microphotometer. A wedge, equalising the two fields, was especially prepared for this purpose. With the aid of the photographic wedge an impression was obtained on Agfa Isopan F film.

The grain of the film and wedge were the same and therefore the impression of the wedge matched the slope of the characteristic curve.

After the measurements of the spectrogram there was obtained the interpolated curve along which the logarithms of the brightness of the lines were obtained as a function of the zenith interval.

There were photographs of further reductions towards the zenith.

The necessary calculation of the absorption in the prisms was done according to Fresnel's formula and the formula of absorption.

Since a prism of complete internal reflection has two reflection planes, the air-glass and glass-air boundaries, then according to the formula

$$J_r = \frac{1}{2} J_e \left\{ \frac{\sin^2(\varphi - x)}{\sin^2(\varphi + x)} + \frac{tg^2(\varphi - x)}{tg^2(\varphi + x)} \right\}$$

the section of the reflected portion can be calculated.

In this formula J_r is the intensity of the reflected waves; J_e is the intensity of the incident waves; φ, angle of incidence; X, angle of refraction.

The angle of incidence can be determined, knowing the zenith interval and the angle of refraction, from the equation

$$n = \frac{\sin \varphi}{\sin \chi}$$

The refraction index, n, of the prisms is found by the known equation

$$n = \frac{\sin \frac{A + \delta}{2}}{\sin \frac{A}{2}}$$

where A is the refraction angle and δ is the angle of minimum diffraction.

The angles A and δ were determined on a goniometer.

The absorption by prisms is calculated from the equation: $J = J_0 e^{-ad}$ where J is the intensity of the passing waves through glass of thickness d; J_0 is the intensity of the incident waves; a is the coefficient of absorption.

The coefficient of transmission under night conditions is determined by the use of Pickering's method [3].

For checking the coefficient of transmission, morning observations were made with the halo photometer constructed by V. G. Fesenkov. The morning observations were made at the same point as the night observations within the astronomical observatory situated on the outskirts of Alma-Ata.

The receiver of the halo photometer contains a selenium photo element of the barrier layer type. The inner part of the tube is darkened and has a series of diaphragms for decreasing the inner reflections. This photometer measures the flux of the halo radiations as well as the solar. The flux of radiation from the halo passes through the tube and falls directly on the photoelement, while that of the sun passes through a thick photographic filter. At the input of the tube of the halo-observation photometer, two discs enter through the revolving arm, shielding the sun, one within the tube, the other at its inlet. The spacing of the discs from the receiver is such that the effect of diffraction at the edges of the shielding disc is eliminated. The sensitivity of the photoelement in relation to the temperature is studied.

The determination of the coefficient of transmission is based on the fact that the atmospheric mass, at which the halo reaches its maximum is directly related to the coefficient of transmission. It is possible to determine the coefficient of transmission when the size of the halo is at a maximum.

Nocturnal photographs were obtained in two-or sometimes three-night exposures. The coefficients of transmission were taken with the calculations of the morning observations. When there were no morning observations due to the change of weather, evening observations were used.

In Table 1 [appended], on the basis of the spectrogram analysis with calculations for the necessary reductions, the brightness of the green line, 5,577A, at the atmospheric boundary is given as functions of the zenith interval.

In Table 2 [appended], the reductions of the calculations according to equation (1) give the theoretical value of the brightness as a function of the zenith interval at various values of the coefficient of transmission for various heights of the emission layer.

As is clear from Table 2, the theoretically obtained distributions of brightness along the zenith intervals at h=0.04 are not far from the experimental results. If the radius of the earth is taken as 6,370 km, then the experimentally obtained height of the emitting layer for the green line, 5.577 A, will be 256.8 km.

We will now present the data of other authors. In 1934, Cabannes and Dufay found that the height of the emitting layer is certainly no higher than 100 km. Elmi and Fernword in 1942 found the height equal to 500 km. In November 1944, Professor Mitra announced that the region of luminescence should measure between 200 and 400 km, corresponding to the F layer of the ionosphere.

In closing, I shall again indicate the excellent agreement of the theoretical values of brightness calculated by the formula of Academician V. G. Fesenkov and the findings based on observations.

I would like to extend my thanks to Academician Fesenkov for his assistance in arranging and conducting the given work.

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[Appended tables follow]

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Table 1

Date	0	45	50	70	75	78	P
1945							
26 Dec	1		1.48		1.64		0.80
1946							
26 Feb	1		1.58		1.78		0.83
30 Jul	1	1.28	1.50	1.65	1.78		0.83
22 Aug	1	1.24	1.46	1.65		1.62	0.82
24 Aug	1	1.32	1.62	1.89		2.00	0.865
27 Aug	1	1.27	1.57	1.78		1.62	0.84
30 Aug	1	1.25	1.55	1.80		1.76	0.84
31 Aug	1	1.28	1.43	1.80		1.81	0.84

Table 2

h = 0.05

Z/P	0.80	0.81	0.32	0.83	0.84	0.85	0.86	0.87	0.88
0°	1	1	1	1	1	1	1	1	1
45	1.25	1.253	1.26	1.264	1.27	1.273	1.280	1.290	1.294
60	1.300	1.310	1.330	1.346	1.360	1.380	1.393	1.400	1.420
70	1.577	1.614	1.648	1.687	1.724	1.760	1.803	1.863	1.880
75	1.510	1.567	1.616	1.670	1.725	1.780	1.845	1.900	1.958
78	1.377	1.408	1.502	1.568	1.639	1.798	1.800	1.807	1.930

h = 0.04

Z/P	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88
0°	1	1	1	1	1	1	1	1	1
45	1.26	1.267	1.274	1.28	1.286	1.293	1.30	1.304	1.31
60	1.50	1.52	1.53	1.556	1.574	1.592	1.61	1.626	1.64
70	1.64	1.682	1.715	1.75	1.792	1.831	1.874	1.91	1.95
75	1.602	1.654	1.709	1.766	1.825	1.893	1.945	2.01	2.07
78	1.51	1.54	1.61	1.686	1.75	1.829	1.91	1.98	2.07

h = 0.03

Z/P	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88
0°	1	1	1	1	1	1	1	1	1
45	1.273	1.28	1.286	1.29	1.298	1.305	1.31	1.316	1.32
60	1.54	1.558	1.575	1.594	1.612	1.63	1.64	1.646	1.689
70	1.71	1.756	1.795	1.835	1.876	1.89	1.962	2.01	2.04
75	1.708	1.756	1.324	1.886	1.953	2.012	2.075	2.175	2.212
78	1.596	1.632	1.742	1.820	1.900	1.95	2.067	2.155	2.246

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